

## **MEDICAL DEVICES**

### **Background of the Invention**

This invention relates to medical devices.

The invention is more particularly concerned with catheters or the like, that are visible under ultrasound observation.

Ultrasound imaging equipment is increasingly being used during surgical procedures to monitor the location of a device within the body. The visibility of a device under ultrasound depends on various factors including the difference between the acoustic impedance of the material of the device and that of the surrounding medium, such as the patient tissue or body fluid within which the device is located. This difference is relatively low with plastic devices such as catheters and may make conventional catheters difficult to locate. Even devices of metal, such as needles, present problems of visibility under ultrasound observation because of the directional nature of the reflections. In some orientations a metal needle may be clearly visible but in other orientations it may be considerably less visible.

Attempts have been made to increase the visibility of medico-surgical devices under ultrasound observation in various ways. The surface of the device may be modified, such as by forming grooves or indentations in its surface. A reflective coating may be applied to the device, such as incorporating bubbles, as described in WO98/19713 and EP0624342. Alternatively, a metal marker may be secured to a plastics catheter. GB2379610 describes a

catheter where the wall is made entirely of a plastics including gas bubbles or where bubble-containing material is in a stripe occupying only a part of the circumference. Although this latter form of catheter has various advantages, it has been found that there is a tendency for the surface of the bore through the catheter to be interrupted by small protrusions where the bubbles break the surface. In some applications, such as for embryo transfer, it is important that the bore of the catheter is as smooth as possible so any interruption of this is a disadvantage. In other applications it may be important instead for the outer surface to be as smooth as possible, or for both the outer and inner surface to be smooth.

#### Brief Summary of the Invention

It is an object of the present invention to provide an alternative medical device.

According to the present invention there is provided a medical device having an elongate portion of plastics material, the portion being extruded with at least a first, inner layer and a second layer on the outside of the inner layer, one of the layers being substantially free of gas bubbles and the other of the layers including gas bubbles dispersed within it to increase the visibility of the device under ultrasound imaging.

The layer substantially free of gas bubbles may be thinner than the other layer. The layer substantially free of gas bubbles may be the inner layer. The second layer may provide an outer surface of the catheter. The device may include a third layer on the outside of the second layer. The second layer may contain gas bubbles and the first and third layers may be substantially free of gas bubbles. The bubbles may be in a region extending around the entire circumference of the device. The bubbles preferably extend in a continuous region along the

length of the device. The gas bubbles may have a size in the range  $0.1\mu$  to  $300\mu$ , preferably having a size in the range  $1\mu$  to  $50\mu$  and most preferably having a size in the range  $5\mu$  to  $10\mu$ . The gas bubbles may be provided by gas-filled polymer microspheres. The device may be a catheter having a bore extending along its length. The inner layer may have an inner surface providing the bore of the catheter. The plastics material is preferably transparent to the eye, the density of bubbles being such as to permit material within the catheter to be viewed by the eye.

An embryo-transfer catheter and its method of manufacture, according to the present invention, will now be described, by way of example, with reference to the accompanying drawing.

#### Brief Description of the Drawing

- Figure 1 is a side elevation view of the catheter;
- Figure 2 is a sectional side elevation view of a part of the catheter of Figure 1 to a larger scale;
- Figure 3 is a cross-section view of the catheter along the line III-III of Figure 2;
- Figure 4 illustrates schematically manufacture of the catheter;
- Figure 5 is a sectional side elevation view of a part of an alternative catheter;
- and

Figure 6 is a cross-section view of the catheter of Figure 5 along the line VI-VI.

#### Detailed Description of the Preferred Embodiments

With reference first to Figures 1 to 3, the catheter comprises an elongate portion in the form of a flexible shaft 1 and a hub 2 joined at the rear end of the shaft. The shaft 1 has a circular section and a bore 10 extending along its length. The shaft 1 opens at its forward, right-hand, patient end 11, which is atraumatically rounded.

The shaft 1 is extruded in two layers 12 and 13. The first, inner layer 12 is of a clear, transparent polyurethane material and is free of gas bubbles so that its inner surface 14, providing the surface of the bore 10, is completely smooth. The second layer 13 is formed around the entire circumference of the first layer 12 and its outer surface 15 provides the outer surface of the catheter. The second layer 13 incorporates small, gas-filled bubbles 22 the size and distribution of which are selected to increase the visibility of the catheter under ultrasound observation. Typically, the gas bubbles have a diameter in the range of about  $0.1\mu$  to  $300\mu$ , preferably being between  $1\mu$  and  $50\mu$  with the most preferred range being about  $5\mu$  to  $10\mu$ . The bubbles 22 extend uniformly through the thickness and around the circumference of the second layer 13 and may be spherical or of any other regular or irregular shape. The second layer 13 is preferably made from the same plastics material as the first layer and the gas bubbles are preferably provided by incorporating gas-filled polymer microspheres such as of the kind sold under the trade mark Expancel ("Expancel" is a registered trade mark of Akzo Nobel). The bubble-filled layer 13 is preferably as thick as possible so as to increase

the visibility of the catheter under ultrasound observation. The inner layer 12 may be relatively thin since its purpose is solely to provide a smooth inner surface for the catheter.

The hub 2 serves to make connection with the shaft 1 and is moulded from a rigid, transparent plastics material, being subsequently bonded with the rear end of the shaft.

The shaft 1 is extruded in the manner shown in Figure 4 using an extrusion machine 20. The machine 20 has two extrusion heads 21 and 22, which are supplied respectively with a polyurethane material 23 and with a polyurethane material 24 containing hollow microspheres. The two materials 23 and 24 are heated and supplied to the respective extrusion heads 21 and 22 so that tubing is formed with the bubble-filled material 24 coextruded as the outer layer 13 about the outside of the inner layer 12, which is of the bubble-free material 23. The shaft 1 can be extruded continuously at low cost, without the need for any subsequent operations apart from attaching the hub 2 and end forming the patient end tip 11.

The bubbles could be formed in various other ways, such as by injecting gas into the melt. Alternatively, chemical foaming agents could be added to the plastics material, such as: azocarbonomides, dinitrosopentmethelyene-tetramine, benzenephonohydrazine, 4,4 oxybis(benzenephonohydrazine), NN<sup>1</sup>dimethyl-NN<sup>1</sup> dinitrosoterephthalamide, azoisobutyronitrile, sodium bicarbonate, terephthalazide or trihydrazinatrazine. Another way of forming the gas bubbles would be by incorporating a liquid into the plastics melt which volatises during the melt process. Alternatively, solid powdered dry ice (carbon dioxide) could be incorporated into the melt so that the particles of dry ice become gas bubbles during

the forming process. It might be possible to use other solids which undergo sublimation in this way. The bubbles could be formed directly as a result of chemical reaction during polymerisation and or alternatively during cross-linking. The bubbles could be formed mechanically by whipping the plastics in a liquid form, such as in the manner used to form latex foam. Alternatively, small particles of a soluble material could be added to the plastics melt and subsequently dissolved away.

The bubble-filled layer need not provide the outer surface of the catheter, especially where the outer surface of the catheter needs to be smoother than can be provided by a bubble layer. Instead, as shown in Figures 5 and 6, the bubble-filled layer 113 could be sandwiched between an inner layer 112 and a third, outer layer 116, the inner and outer layers being of the same material and being free of bubbles. Preferably, the inner layer 112 and the outer layer 116 are relatively thin and the middle, bubble-filled layer 113 is relatively thick, to maximise the ultrasound reflecting properties of the catheter. This three-layer tube is also made by co-extruding the three layers with one another. Alternatively, where it was necessary for the outer surface of the catheter to be smooth and there was no need for the bore to be smooth, the catheter could just have two layers where the outer layer was thin and bubble-free and the inner layer was thicker and contained bubbles.

The catheter could have any number of additional layers with one or more layers containing bubbles.

Catheters according to the present invention can be made having good visibility under ultrasound imaging without producing multiple echoes. They can produce a good image

regardless of the orientation of the catheter shaft. The shaft can be made sufficiently transparent to ultrasound energy to enable material flowing along the bore of the catheter to be observed on the ultrasound image.

Because the catheter does not require any coating or separate marker there is no need for subsequent assembly operations and there is no risk of detachment. The catheter can be made of conventional, medically-approved materials so does not present any new risk to the patient. The outer surface of the three-layer catheter can be smooth so the catheter can be inserted or slid through an outer tube with low friction. A smooth bore can be provided to a catheter to ensure free flow along the bore, which can be important where the catheter is used to transfer embryos. In other applications, a smooth inner surface may reduce the accumulation of biofilm in the catheter. The catheter can be made without the need for metal components, which can be an advantage where the catheter is used while the patient is being viewed by magnetic imaging techniques. The catheter can be completely transparent to x-rays or the plastics from which it is formed could incorporate an x-ray opaque filler, such as barium sulphate.

The bubble size and density can be selected so that the optical transparency of the plastics forming the shaft remains sufficient to enable material flowing along the shaft to be viewed by the eye.

It is not essential for the bubbles to be provided around the entire circumference of the bubble-containing layer, instead, the bubbles could just be provided along a longitudinal stripe in the layer. This arrangement can be used where the shaft needs to have increased

clarity so that material within the catheter can be seen by the eye. Alternatively, the bubbles could be contained around the entire circumference of the layer apart from a bubble-free longitudinal strip. The bubble region need not be continuous along the length of the catheter. Instead, discrete separate regions with bubbles could be separated from one another along the length of the catheter by regions without bubbles. A shaft for such a catheter could be made by blowing gas into the plastics forming the bubble layer and by interrupting the gas flow. Where the bubbles are contained within a stripe, this could be interrupted to make it discontinuous by extruding the stripe using two auxiliary extruders, one having material with hollow microspheres and the other having material without the microspheres. Alternate extruders would be switched on and off so that the stripe could have sections containing bubbles separated from one another by sections without bubbles. A catheter having a layer with an interrupted bubble region may give a clearer ultrasound indication of movement of the catheter along its length and may also enable clearer observation of material flowing along the catheter both by ultrasound and by the eye.

The invention is not confined to catheters but could be used in other medical devices such as cables and medical devices without a bore, or with more than one bore.